



This document contains Part 1 (pp.75–83) of Chapter 3 of the National Coastal Condition Report III.

*The entire report can be downloaded from
<http://www.epa.gov/nccr>*

National Coastal Condition Report III
Chapter 3: Northeast Coast Coastal Condition
Part 1 of 3

December 2008

CHAPTER 3

Northeast Coast Coastal Condition



Northeast Coast Coastal Condition

As shown in Figure 3-1, the overall condition of the collective coastal waters of the Northeast Coast region is rated fair to poor, with an overall condition score of 2.2. The water quality index for the region is rated fair, the sediment quality index is rated fair to poor, the coastal habitat index is rated good to fair, and the benthic and fish tissue contaminants indices are rated poor. Figure 3-2 provides a summary of the percentage of coastal area in good, fair, poor, or missing categories for each index and component indicator. This assessment is based on data collected from 723 water-, 507 sediment-, and 890 benthic-monitoring locations throughout the Northeast Coast coastal waters. Please refer to Chapter 1 for information about how these assessments were made, the criteria used to develop the rating for each index and component indicator, and any limitations of the available data.

The Northeast Coast region contains diverse landscapes, ranging from the mountains, forests, and rocky coastal headlands of Maine to the coastal plain systems of the Mid-Atlantic states. The ratio of watershed drainage area to the area of estuary water in the Northeast Coast region is relatively small compared to the ratios in the Southeast Coast and Gulf Coast regions. Cape Cod, MA, represents a major biogeographic transition area for the region's coastal area, dividing the more arctic waters to the north of Cape Cod (Acadian Province) from the warmer, temperate waters to the south of Cape Cod (Virginian Province). The relatively larger average tidal ranges of 7 to 13 feet in the Acadian Province contribute to greater tidal mixing and flushing, in contrast to the tidal ranges of 7 feet or less in the coastal waters of the Virginian Province. The region's Chesapeake Bay, the largest estuary in the United States, is considered microtidal in character, having average tidal ranges of less than 3 feet (Monbet, 1992; Hammar-Klose and Thieler, 2001). The total area of Chesapeake Bay is 4,404 mi², representing 59% of the coastal area of the Northeast Coast region. The large size and volume of the Bay and the relatively small tidal range contribute to a freshwater

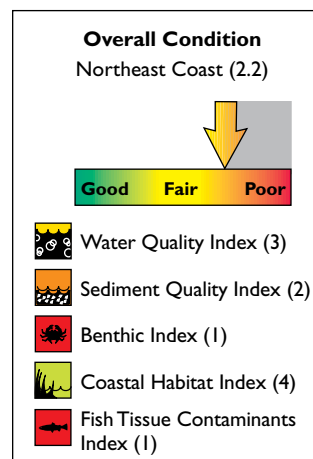


Figure 3-1. The overall condition of Northeast Coast coastal waters is rated fair to poor (U.S. EPA/NCA).

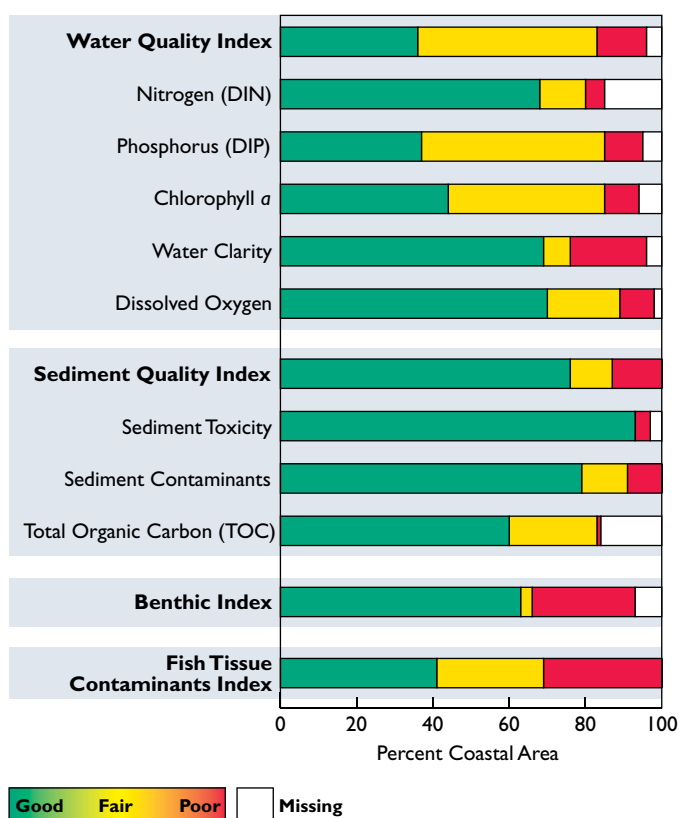


Figure 3-2. Percentage of coastal area achieving each ranking for all indices and component indicators—Northeast Coast region (U.S. EPA/NCA).

residence time of 7.6 months, much longer than that of other estuaries in the Northeast Coast region (Nixon et al., 1996). In contrast, Delaware Bay, Narragansett Bay, and Boston Harbor have freshwater residence times of 3.3, 0.85, and 0.33 months, respectively (Dettmann, 2001). Because of the size of Chesapeake Bay, conditions in this estuary heavily influence area-weighted statistical summaries of Northeast Coast conditions.

The Northeast Coast region, which includes the coastal waters and watersheds of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Virginia, is the most densely populated coastal region in the United States (Figure 3-3). In 2003, the coastal population of the Northeast Coast region was the largest in the country, with 52.6 million people, representing 34% of the nation's total coastal population. Although coastal counties along the Northeast Coast showed the slowest rate of population increase (58%) between 1980 and 2003, the region gained the second-largest number of people (almost 8 million) of all U.S. regions during this time. Figure 3-4 presents population data for Northeast Coast coastal counties since 1980 (Crossett et al., 2004).

Although the data presented in this chapter are summarized on a regional level, they are publicly accessible and can be used to summarize conditions by biogeographic province, state, and—where sufficient data are available—by waterbody. The NEP CCR (U.S. EPA, 2006b) is an example of how these data may be assessed at a finer scale.



The NCA monitoring data used in this assessment were based on single-day measurements collected at sites throughout the U.S. coastal waters (excluding the Great Lakes) during a 9- to 12-week period in late summer. Data were not collected during other time periods.

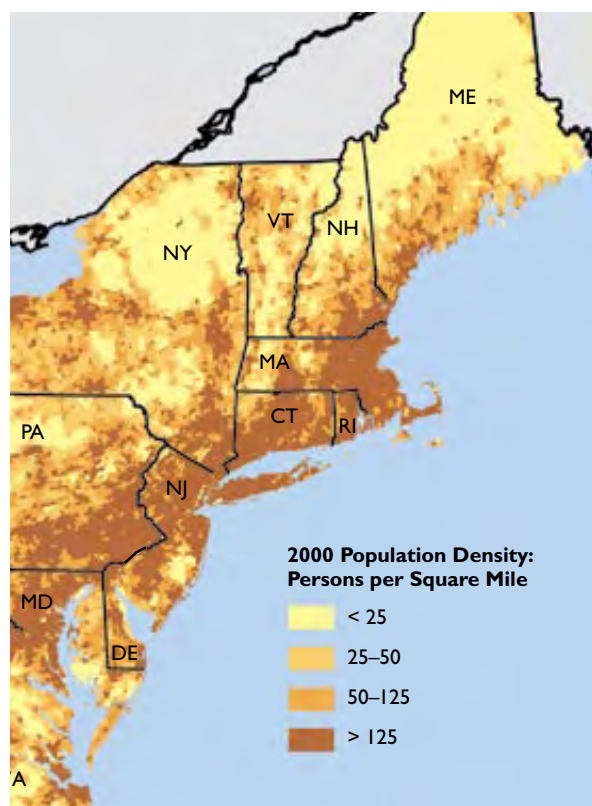


Figure 3-3. Human population density by county for watersheds that drain to the Northeast Coast (U.S. Census Bureau, 2001).

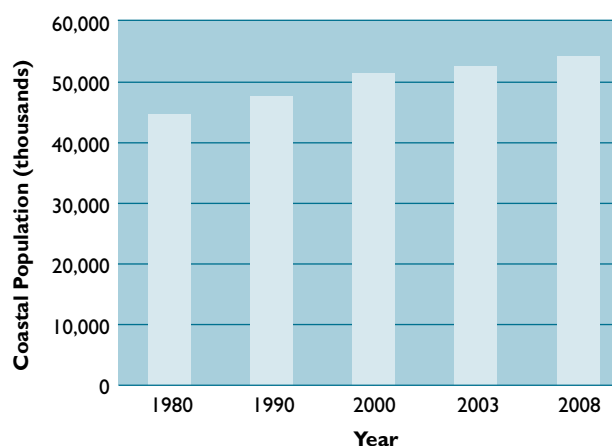


Figure 3-4. Actual and estimated population of coastal counties in Northeast Coast states, 1980–2008 (Crossett et al., 2004).

Coastal Monitoring Data— Status of Coastal Condition

All sampling sites that contributed data for this report were selected at random according to probabilistic sampling designs and were generally sampled during the summer months of 2001 and 2002 by states participating in the NCA; however, there were some exceptions to this scheme. Several areas, including parts of Maine, Massachusetts, Rhode Island, Connecticut, and New York (in the case of water quality assessment), contributed data only in 2001, either because of planned non-participation in 2002 or because of concerns regarding data quality. Chesapeake Bay was not sampled as part of the NCA survey in 2001 or 2002; therefore, the most recent representative data available from other programs were used for the assessment of this waterbody. Specifically, water quality conditions and benthic community data from 2001 and 2002 were provided by the Chesapeake Bay Program (CBP), and sediment quality data for the Bay were collected during NOAA's sediment triad cruises from 1998 through 2001.

Conditions for the Northeast Coast region were calculated and expressed in terms of the percentage of coastal area rated good, fair, or poor, or for which data were missing. For the areas not sampled in the 2002 survey, the 2001 station-area weights were doubled to ensure approximately equivalent representation on a per-area basis throughout the Northeast Coast region. An exception to this method of areal weighting was the fish tissue contaminants index, for which survey results were



The sampling conducted in the EPA NCA survey has been designed to estimate the percent of coastal area (nationally or in a region) in varying conditions and is displayed as pie diagrams. Many of the figures in this report illustrate environmental measurements made at specific locations (colored dots on maps); however, these dots (color) represent the value of the index specifically at the time of sampling. Additional sampling would be required to define temporal variability and to confirm environmental condition at specific locations.

unweighted and reported as the percentage of fish samples analyzed in good, fair, or poor condition. Data from the 2002 survey were not included in the trend analysis discussed later in this chapter.



Water Quality Index

The water quality index for the coastal waters of the Northeast Coast region is rated fair, with 13% of the coastal area rated poor and 47% of the area rated fair for water quality condition (Figure 3-5). The water quality index was based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen.

Most of the Northeast Coast sites rated poor for water quality were concentrated in a few estuarine systems, in particular New York/New Jersey Harbor; some tributaries of Delaware Bay; the Delaware River; and the western and northern tributaries of Chesapeake Bay. Although signs of degraded water quality impacts are evident throughout the Northeast Coast region, the water

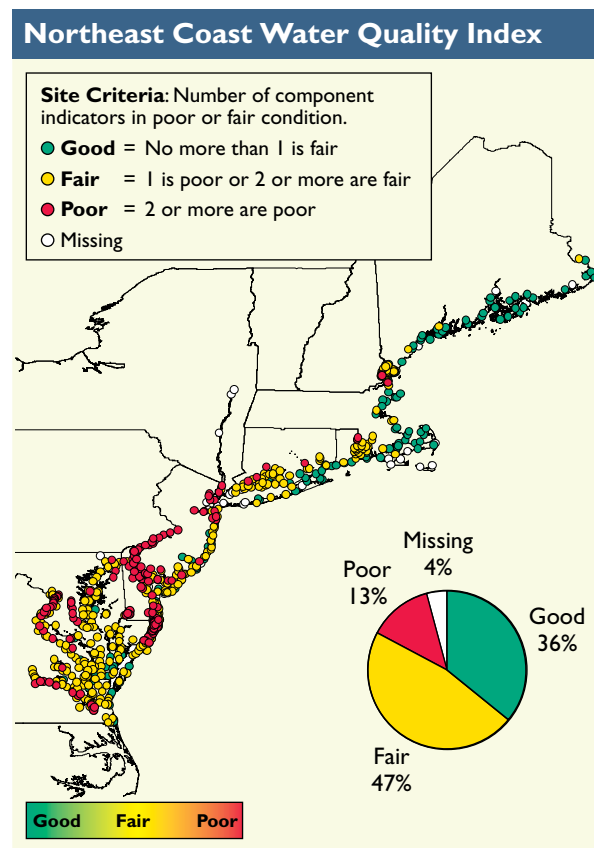


Figure 3-5. Water quality index data for Northeast Coast coastal waters (U.S. EPA/NCA).

quality index indicates that the degradation was more evident in the coastal waters of the Virginian Province than in the coastal waters of the Acadian Province. Generally, the relatively open rocky coasts; cold, salty waters; and high tidal ranges of the Acadian Province favor well-mixed conditions. In contrast, the historically unglaciated parts of the Virginian Province have extensive watersheds that funnel nutrients, sediment, and organic material into secluded, poorly flushed estuaries that are much more susceptible to eutrophication. The pattern of water quality degradation in the Northeast Coast region is also influenced by the distribution of population density (see Figure 3-3).

Nutrients: Nitrogen and Phosphorus

The Northeast Coast region is rated good for DIN concentrations, with only 5% of the coastal area rated poor for this component indicator. Poor DIN concentrations (DIN concentrations greater than 0.5 mg/L) were largely confined to stations in New York/New Jersey Harbor; the western tributaries of Chesapeake Bay; the Delaware River; and the Delaware Inland Bays.

The Northeast Coast region is rated fair for DIP concentrations, with 58% of the coastal area rated fair or poor for this component indicator. The highest DIP concentrations were most evident at stations in parts of the New York/New Jersey Harbor and Delaware River and were found to a lesser extent in Narragansett Bay, Long Island Sound, and the western tributaries of Chesapeake Bay. Good conditions (low DIP concentrations) were notable in Cape Cod Bay, coastal Rhode Island waters, and the mainstem of Chesapeake Bay.

Chlorophyll *a*

The Northeast Coast region is rated fair for chlorophyll *a* concentrations, with roughly 9% of the coastal area rated poor and another 41% of the area rated fair for this component indicator. Generally, the broad pattern of chlorophyll *a* concentrations is similar to that of nutrients, with chlorophyll *a* levels much higher to the south of Cape Cod (Virginian Province) than to the north (Acadian Province). Chlorophyll *a* concentrations mirror nutrient levels in the Maryland Coastal Bays, Chesapeake Bay tributaries, and much of

the Northeast Coast coastal waters; however, there is little apparent spatial correlation between chlorophyll *a* and nutrient concentrations in the Chesapeake Bay mainstem, Delaware Bay, or New York/New Jersey Harbor areas. Spatial patterns in nutrient and chlorophyll *a* concentrations differ for a number of reasons. Algae may not be able to use nutrients effectively in very turbid water or in regions with high flushing rates; dissolved nutrient concentrations may be low due to nutrient uptake by phytoplankton blooms; or locations of peak nutrient and biomass concentrations may not coincide in space or time.

Water Clarity

The Northeast Coast region is rated fair for water clarity, with 20% of the coastal area rated poor for this component indicator. Water clarity reference levels varied across the Northeast Coast region (see Chapter 1 for additional information). The box below shows the criteria for rating a site in poor condition for water clarity in estuarine systems that have differing levels of natural turbidity.

Coastal Areas	Criteria for a Poor Rating (Percentage of Ambient Light that Reaches 1 Meter in Depth)
Chesapeake Bay Estuarine System	< 20%
Delaware River/Bay Estuarine System	< 5%
All remaining Northeast Coast coastal waters	< 10%

Dissolved Oxygen

Dissolved oxygen is rated fair for the Northeast Coast region, with 9% of the coastal area rated poor for this component indicator. Based on the NCA and CBP data collected in 2001 and 2002, the stations rated poor were primarily located in Long Island Sound and the isolated, deep channels of the Chesapeake Bay mainstem and western tributaries. Although not reflected by the data collected for this assessment, other areas of the Northeast Coast may experience low dissolved oxygen levels on a diel basis or due to prevailing wind events. Fair dissolved

oxygen conditions were measured in another 19% of the coastal area, notably at stations in Chesapeake Bay, Long Island Sound, and Narragansett Bay. Dissolved oxygen levels were rated good in more than two-thirds of the Northeast Coast coastal area. A recent review of factors affecting the extent of hypoxic bottom water in Chesapeake Bay can be found in Hagy (2002), Hagy et al. (2004), and Kemp et al. (2005). In addition, more intensive and complementary monitoring programs in upper Narragansett Bay documented episodic dissolved oxygen depletion events (dissolved oxygen < 2 mg/L) during short time periods (Deacutis et al., 2006).



Sediment Quality Index

The sediment quality index for the coastal waters of the Northeast Coast region is rated fair to poor, with 13% of the coastal area rated poor for sediment quality condition (Figure 3-6). Data were missing for less than 1% of the coastal area. This index is based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC. Hot spots of poor sediment quality were evident at stations in Narragansett Bay, western Long Island Sound, New York/New Jersey Harbor, and the upper portions of the Chesapeake Bay and Potomac River. To a large extent, the pattern of the sediment quality index for the Northeast Coast region mirrors the pattern of sediment contamination, a component indicator of this index.

Sediment Toxicity

The Northeast Coast region is rated good for sediment toxicity, with about 4% of the coastal area rated poor for this component indicator. Sites rated poor for sediment toxicity were located predominantly in parts of Cape Cod Bay, western Long Island Sound, New York/New Jersey Harbor, and the tidal-fresh water parts of Delaware Bay. In a previous report (U.S. EPA, 2004a), a generally weak statistical relationship between sediment contamination and amphipod survival was found and may reflect, in part, the strict criterion of mortality used to characterize toxicity in the amphipod assay. This weak relationship also highlights the need for a more complete analysis of the bioavailability of the toxicants, i.e., an analysis that

considers the effect of equilibrium partitioning and the mitigating effects of sequestering toxicants with sulfides or organic carbon (DiToro et al., 1991; U.S. EPA, 1993; Daskalakis and O'Conner, 1994).

Sediment Contaminants

The Northeast Coast region is rated fair for sediment contaminant concentrations, with 9% of coastal area rated poor and 12% of the area rated fair for this component indicator. Stations rated poor for sediment contaminants were clustered in areas neighboring major urban centers. These areas included Narragansett Bay, New York/New Jersey Harbor, western Long Island Sound, upper Chesapeake Bay, and the upper Potomac River. Elevated levels of metals (e.g., arsenic, chromium, mercury, nickel, silver, and zinc), PCBs, and DDT were primarily responsible for the poor sediment contaminant ratings.

Sediment TOC

The Northeast Coast region is rated good for sediment TOC because only 1% of the coastal area

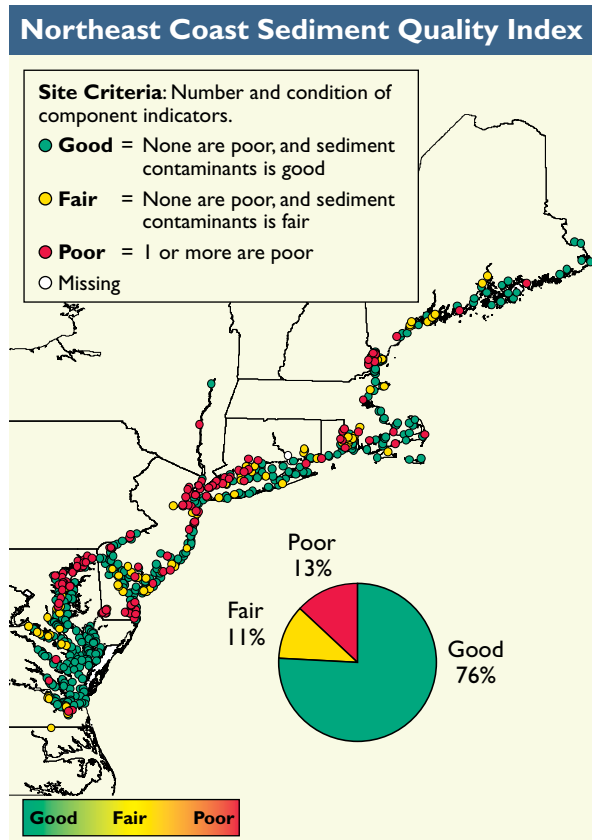


Figure 3-6. Sediment quality index data for Northeast Coast coastal waters (U.S. EPA/NCA).

was rated poor. In addition, 23% of the coastal area was rated fair, and 60% was rated good for this component indicator. Generally, elevated TOC levels were found at stations in the same locations as contaminated sediments. The high percentage of missing data (16%) for this component indicator reflects concerns about the quality of the TOC data analyzed for Connecticut's coastal waters.



Benthic Index

The benthic index for the coastal waters of the Northeast Coast region is rated poor, with 27% of the coastal area rated poor for benthic condition (Figure 3-7). The Northeast Coast region features two distinct biogeographic provinces: the Acadian Province (north of Cape Cod) and the Virginian Province (south of Cape Cod). Two separate benthic indices were developed to evaluate the unique benthic communities of these provinces: the Acadian Province Benthic Index (Hale and Heltshe, 2008) and the Virginian Province Benthic Index (Paul et al., 2001). Because of the way the indices were developed, the Acadian Province Benthic Index has three rating categories (good, fair, and poor), whereas the Virginian Province Benthic Index has only two rating categories (good and poor).

The benthic condition of the Acadian Province is very different from the benthic condition of the Virginian Province. Coastal conditions in the Acadian Province are more oceanic and have higher bottom-water salinity than those in the Virginian Province. In the northern waters (Acadian Province), benthic communities were sampled at sites with an average depth of 57 feet, 36 feet deeper than the average depth of stations sampled in the Mid-Atlantic coastal waters in the southern portion of the Virginian Province. Poor benthic condition is evident at stations in many sections of the Virginian Province, including Chesapeake Bay; portions of Delaware Bay; New York/New Jersey Harbor; western Long Island Sound; and upper Narragansett Bay. In contrast, most sampling stations in the Acadian Province show good or fair benthic condition. The differences by province reflect exposure to different stress levels by the benthic communities.

Northeast Coast Benthic Quality Index

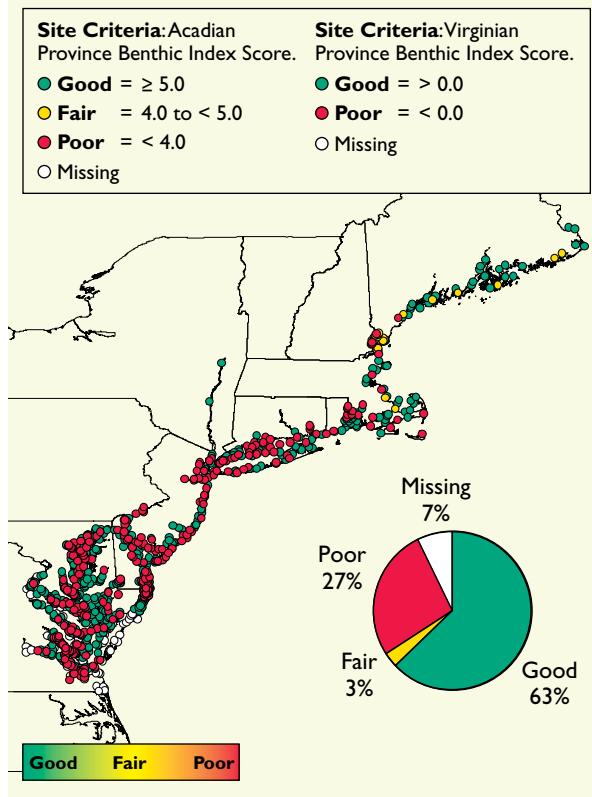


Figure 3-7. Benthic index data for Northeast Coast coastal waters (U.S. EPA/NCA).



Coastal Habitat Index

Wetlands are threatened by many human activities, including loss and destruction due to land development, eutrophication, and the introduction of toxic chemicals. Losses can also result from land subsidence, sea-level rise, and the introduction and spread of exotic species (e.g., nutria). Ecologists estimate that more than one-half of the coastal wetlands of the Northeast Coast region have been lost since pre-colonial times. Although modern legislation has greatly slowed the rate of habitat loss, the Northeast Coast region lost 650 acres between 1990 and 2000, which amounts to a loss of 0.14% over 10 years. The rate of wetland loss for this time period was the lowest percent loss for all regions of the conterminous United States. Based on the calculated coastal habitat index value, the coastal habitat index for the Northeast Coast is rated good to fair.



Highlight

Comparing Two Benthic Indices Applied to Monitoring Data from NY/NJ Harbor

Scientists and managers have worked diligently to answer the question “Is this place relatively clean, or is it stressed?” Evaluating a site can involve analyzing the levels of chemical and physical stress on bottom-dwelling communities by directly measuring sediment chemical concentrations, relative toxicity, and grain size. In addition, characterizing the salinity of the overlying water and the structure and composition of the benthic community reflects exposures to chemical and physical stresses in the environment. Indices of benthic condition have been developed to examine the complex conditions that exist in the sediments, quantifying those conditions as a single numeric value. To help evaluate the condition of the New York/New Jersey (NY/NJ) Harbor, two different, independently developed benthic indices were applied to Regional Environmental Monitoring and Assessment Program (REMAP) monitoring data from 1998 (Adams and Benyi, 2003). The resulting index ratings were compared to evaluate the similarities and differences between classifications developed by applying different benthic indices to the same set of data.

The two benthic indices used in this assessment were the Virginian Province Benthic Index and the Benthic Index of Biotic Integrity (B-IBI). The Virginian Province Benthic Index (Paul et al., 2001) was developed in the EMAP-Virginian Province (VP) for use in the waters along the East Coast of the United States from Cape Cod to the mouth of the Chesapeake Bay and has been used to assess NCA data for the Virginian Province in this NCCR III. The B-IBI (Adams et al., 1998) was developed specifically for evaluating the benthic communities of the NY/NJ region. The approaches used in developing the two indices were quite different. The Virginian Province Benthic Index uses statistical techniques to evaluate appropriate metrics, whereas the B-IBI uses a method that was developed for freshwater systems and involves applying values to select metrics based on established criteria derived from reference stations (see box). Validation of the NY/NJ Harbor B-IBI using independent data from 72 sites in the Harbor showed that the index was 93% effective at distinguishing anthropogenically stressed sites from reference sites (Adams et al., 1998).

Virginian Province Benthic Index, developed using discriminant analysis, is characterized by the following three metrics:

- 1) Gleason's Diversity Index, adjusted for salinity
- 2) Expected number of tubificids, adjusted for salinity
- 3) Abundance of spionid polychaetes (Strobel et al., 1995).

Gleason's Diversity Index measures the variety of invertebrates in the sediment. Tubificids are a type of worm found, but not exclusively, in enriched areas, and salinity adjustment makes the presence of tubificids of great importance in low-saline areas, but not of high importance in estuarine areas. Spionid polychaetes are also a type of worm.

Benthic Index of Biotic Integrity (B-IBI), developed by testing the classification efficiency of candidate measures, is characterized by the following five metrics:

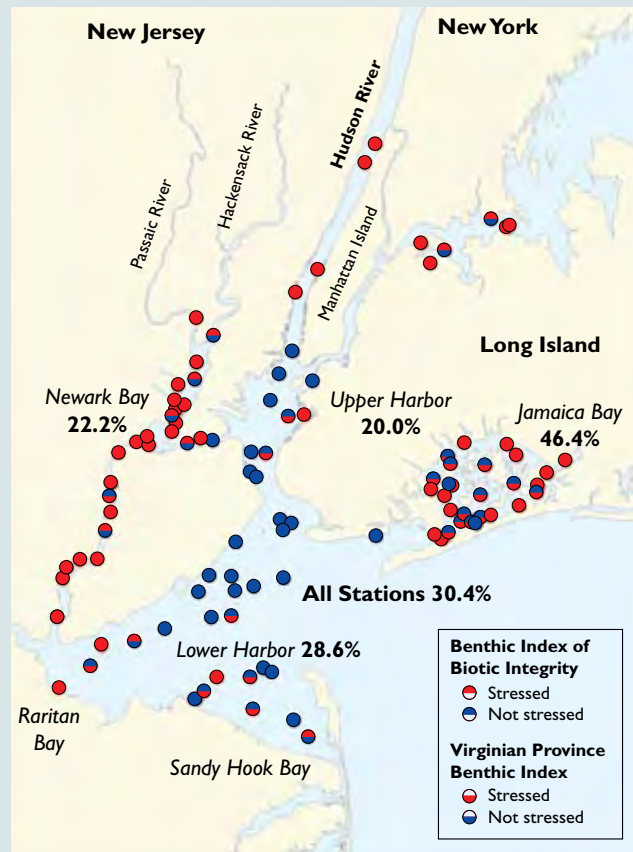
- 1) Number of species
- 2) Abundance of species
- 3) Biomass
- 4) Percent of total abundance indicative of pollution
- 5) Percent of total abundance sensitive to pollution.

The B-IBI is similar to the Index of Biotic Integrity developed for freshwater benthic communities by Karr (Kerans and Karr, 1994). Threshold values for these metrics were defined for two salinity ranges (polyhaline and euryhaline) and two sediment types (mud and sand). The B-IBI was calculated by scoring each selected metric based on whether its threshold value approximated (5), deviated slightly (3), or deviated greatly (1) from conditions at the best reference sites. Those metrics were then averaged.

The REMAP sampling stations were selected using a design common in EMAP programs (probabilistic, stratified-random design), with 28 stations located in each of the four subbasins. Benthic macroinvertebrate data from two replicate samples were averaged, and the benthic index results were calculated for each station. Overall, disagreement in the classifications resulting from analyses using the Virginian Province Benthic Index and B-IBI occurred at only 30% of the stations overall. In the map, a filled circle represents each station, with the top half representing the B-IBI classification and the bottom half representing the Virginian Province Benthic Index classification. When the halves of the circle are colored differently, they disagree. The percentage of disagreement between the results obtained using the two indices is included on the map for each subbasin.

Within the four subbasins, the percentage of stressed sites ranged from a low of 8% to a high of 93% using the B-IBI, and from 32% to 93% using the Virginian Province Benthic Index. In most subbasins, the percent of stations stressed was similar. For example, in the Upper Harbor, both indices identified 55% of stations in the subbasin as stressed, and the two indices had the strongest agreement by station. In contrast, the percent of stressed stations in Jamaica Bay was 46% for the B-IBI and 93% for the Virginian Province Benthic Index. In this subbasin, the Virginian Province Benthic Index classified two times as many stations as stressed as did the B-IBI (26 and 13 out of 28, respectively). In addition, the highest percentage of disagreement between the results obtained using the two indices (46%) occurred in this subbasin.

The Virginian Province Benthic Index and B-IBI use different metrics to come to an understanding of a station's ecological health status. Although there might appear to be a fair amount of disagreement between the classifications of stations, the overall agreement for the entire harbor was 70%. In areas where there was disagreement, it is worth examining the reasons for the differences. At stations where the B-IBI indicated stress and the Virginian Province Benthic Index did not, the primary metrics driving the B-IBI classification were biomass and the abundances of pollution-sensitive and pollution-indicative species; none of these metrics are measured in the Virginian Province Benthic Index. Since these two indices are used as indicators of stress, it would be valuable to examine other metrics, such as chemical concentrations of metals and organics in the sediment, to determine whether chemical stresses are occurring.



Benthic index classifications and percent disagreement between B-IBI and the Virginian Province Benthic Index classifications for REMAP sampling stations in the NY/NJ Harbor area (U.S. EPA).